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CORRELATION ANALYSIS OF DAIRY PRACTICES AND MANAGEMENT FACTORS ON NEW YORK DAIRY FARMS

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Foreword

This publication is part of a study supported by a special temporary grant to the Agricultural Experiment Station at Cornell University by Agway Inc. of Syracuse, New York.

Correlation analysis studies of dairy farm management factors are limited. The data used in this study were collected from two sources: Dairy Herd Improvement Association (DHIA) records and the Cornell Farm Business Management Projects (FBR). Using modern computer techniques, the information was merged for 413 dairy farms that had both DHIA and FBR records for the year 1974. Intercorrelations for selected variables were calculated and are reported in this publication.

J. Clarke Fowers, an agricultural economics student in the Cornell Graduate School, conducted this study under the supervision of C. A. Bratton, professor of farm management and chairman of his graduate committee. H. R. Ainslie, extension leader and professor in animal science, was a member of the graduate committee and provided valuable assistance in the study.

The author wishes to acknowledge the encouragement given by Dr. Lewellyn B. Mix of Agway Inc. to pursue the investigation and publication of these findings related to dairy management practices.

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Introduction

Farm management research has two general objectives. First, to evaluate the managerial performance of farmers and second, to provide information to teach farmers and prospective farmers how to best achieve their farm operation goals. It is assumed that superior labor and management income per operator is a primary continuous farm operation goal.

In working to accomplish these objectives, the Department of Agricultural Economics at Cornell University compiles annual economic and financial data from selected dairy farms across the state. These data are summarized and published as the annual New York State Dairy Farm Management Business Summary. The summary publication lists financial and economic data for all farms and average values for selected farms by specific cross tabulation categories. The tables are arranged by farm size, rates of production, labor efficiency, capital efficiency, and cost control, with supplemental information also included.

Over the years, the annual farm business summary has been helpful to those in the dairy industry. The tables in the annual publication indicate general relationships among variables. Trends for selected groups of dairy farms can also be observed from the data.

The cross tabulation type of analysis, while making a significant contribution to farm management research in the state, is limited in its ability to quantify and establish direct positive and negative relationships among farm management variables. Cross tabulation usually establishes the direction of a relationship but does not quantify the significance of that relationship.

Correlation analysis, particularly simple correlation analysis, is a tool used by statisticians to measure the simple linear relationship between two variables. Simple correlation analysis can be used in conjunction with cross tabulations to quantify and describe the relationship inherent in the farm management process. Thus, through the use of correlation coefficients, farm management research can better accomplish its general objectives.

Methodology

For this study, farm business records (FBR) from the Department of Agricultural Economics at Cornell were combined with the dairy herd improvement records (DHIA) from the Cornell Animal Science Department. Records for 1974 were used and 413 dairy farms that participated in both DHIA and FBR programs were identified. Production and income data from these farms were merged on computer tape. The correlation coefficient calculations were performed by the computer using the following formula:

$$r_{xy} = \frac{\sum_{i}^{n} (X_i - \overline{X})\ (Y_i - \overline{Y})}{\sqrt{\sum_{i}^{n} (X_i - \overline{X})^2 \sum_{i}^{n} (Y_i - \overline{Y})^2}} \qquad \text{Where} \quad \overline{X} = \frac{\sum_{i}^{n} X_i}{N}$$

r_{xy} = Simple correlation coefficient between X and Y

r^2 = Variation

Correlation analysis in this study is used to identify and measure the interrelationships of the variables from the FBR and DHIA information systems. The correlation matrix of 36 variables resulted in 648 correlation coefficients. The complete matrix appears in the appendix. Some of the 648 correlations have no direct meaning to the farm management process and others are subtle in their contributions. The significant correlations were extracted from the table and grouped in management categories. These are discussed in the text.

When using a correlation, care must be exercised since its mathematics assumes independence from other factors. This is a questionable assumption among farm management variables since some variables interact in shaping the economy of a farm. The movement of one variable may influence the values of others. Further, simple linear correlation is a statistical measurement between two independent variables. It does not measure multiple variable effects. This would require multiple correlation and regression analysis which is beyond the scope of this publication.

If the simple correlations are squared and the result multiplied by 100, an estimate of the variance explained by each variable is obtained. Many explain a very small amount of variation and are labeled insignificant and not statistically different from a zero correlation. This is due, in part, to the multiple variable interaction described above. In this publication, the test of statistical significance is at the .05 level of committing a Type 1 error, and the .10 level where specified. The significance level of any correlation coefficient is by mathematical definition, directly tied to the number of valid observations and the magnitude (not direction) of the coefficient. In the bivariate correlation, the error in predicting the variable value is sure to be large when the r^2 value is low. As the r^2 value approaches absolute 1 this error diminishes.

The problem of multiple variable interaction can be diminished by using partial correlation analysis. This analysis is bivariate but adjusts for the effects of extraneous variables on the coefficient. For example, first order partial correlation would control for the effects of variable x on y and z while determining the correlation coefficient of y and z. Second order would be the same except a second variable, w for example, would be controlled.

Again, the statistical tool requires a linear relationship and normality of distribution within the variables. The degree to which this assumption is violated will be directly associated with the meaning of any partial correlation coefficient. A separate section in this study will include partial correlation analysis, especially as associated with operator income.

Use of the computer simplifies sorting the data into subfiles and performing correlations within each subfile. The 413 farms were sorted into seven herd size subfiles and correlations performed within each herd size. This same procedure was followed for seven income levels. These subfile correlation coefficients follow the section describing partial correlation.

Definitions of Measures Used

Four measures used in the farm business summaries, and fifteen measures from the dairy herd improvement records are defined below. These are general definitions for working purposes in this research. Details concerning the calculation procedures can be obtained from the Department of Agricultural Economics or the Department of Animal Science.

Labor and management income per operator reflects the dollar return to the farmer-operator for time, knowledge and skills to operate the entire farm business, and this variable will be referred to as operator income which has identical meaning. For calculation details, see Cornell's A.E. Res. 77-9.

Average number of cows is a 12-month average of the milk cows as reported in the farm business summary.

Number of cows per person is calculated by dividing herd size by the person equivalent.

Milk produced per cow is the total pounds of milk produced by each cow as computed from the twelve monthly dairy herd improvement sample weights. The herd average was used in this study for all dairy management practices.

Milk sold per cow is the yearly poundage of all milk sold divided by average number of cows. This is lower than milk produced per cow by the amount used by the family, wasted, or fed to the animals.

Butterfat test is the herd average for the twelve monthly dairy herd improvement samples tested.

Concentrates fed is the calculated yearly average pounds of concentrates fed per cow in the herd. The D.H.I. supervisor records the pounds of concentrates fed during each monthly test period. These are aggregated for the yearly figure.

The percent net energy figures are calculated for concentrates, succulents (silages), dry hay, and pasture. It reflects the relative amount of available therms (calories) the cow gets from each source.

Bodyweight of all cows, rounded to the nearest ten pounds, is the average weight of all cows in the herd during the year and is obtained by taping the animal.

Bodyweight at first calving is also rounded to the nearest ten pounds. The bodyweight at first calving is likely to be lower for heifers that calve earlier.

Age at first calving is expressed in months. Heifers that cycle earlier can be bred earlier.

Projected minimum calving interval is the herd average of the number of months between calves.

Breedings per conception is the number of times a cow is bred before she is settled.

Days dry measures the number of days a cow is not milked per calving interval.

Percent of days in milk is an aggregated measure reflecting efficiency in days dry, days open, and projected minimum calving interval. It is the number of days milked divided by the number of days on test (usually 365).

Percent leaving the herd was calculated by dividing the number of cows leaving the herd during the year for purposes other than dairy (slaughter) by the herd size.

Age of all cows, expressed in months, is the average of all milk cows in the herd during the year.

The feeding index equals the reported total net energy fed per cow divided by the calculated maintenance and production requirements, multiplied by one hundred. It is an efficiency measure of the feeding practices being followed.

Income over value of feed is the computed value of the milk produced minus the value of all feed fed. Value of feed is calculated by the farmer and dairy herd improvement representative.

Correlation With Operator Income

The purpose of this section is to observe the correlation for selected farm business factors and dairy management practices using the combined data on 413 New York dairy farms.

The seven tables in this section contain the correlation coefficients and are arranged by general management areas. Some repetition of coefficients exists due to the overlapping of management areas. These tables are compiled from the appendix table 1 and are designed to highlight the more important correlations in each management area.

The discussion accompanying the tables is limited to the more significant observations and is not intended to be a complete descriptive analysis of all coefficients. It provides a guide in developing an understanding of the correlations.

Correlation coefficients for selected variables when correlated with labor and management income per operator (operator income) are reported in table 1. Cost of producing a hundredweight of milk showed the highest correlation coefficient with operator income (-.820). This coefficient is expected since it encompasses the major economic cost factors and relates them to labor and management income. Feed and crop expense per hundredweight of milk, which measures major cost items, had a high correlation coefficient with a -.299.

Moving to the positive correlations in table 1, pounds of milk sold per man had the highest correlation with operator income with .367. This measure is used to indicate labor efficiency and in cross tabulation studies is often referred to as the most important single factor affecting income. The relatively high coefficient substantiates this point. However, it should be observed that size of business, rates of production, and efficient labor practices, are interrelated elements in this measure. Pounds of milk sold per man is an easily calculated measure of labor accomplishment or output per man and can be a useful management measure.

Efficiency and productivity are important factors relating to income. Milk sold per man and milk sold per cow have relatively large coefficients that identify this importance.

Pounds of milk sold per cow, a standard measure of rates of production, and operator income had a positive correlation coefficient of .358. This coefficient verifies the variable as an important factor affecting labor and management income per operator. The magnitude of the correlation suggests this may be the most important single business factor relating to operator income. However, a number of dairy management practices contribute to this measure, so when examining this relationship the dairy management factor correlation coefficients must be taken into consideration.

The correlation coefficient for total pounds of milk sold and labor and management income per operator was .340. This number quantifies the relationship of size (as measured by milk sold) to profitability. The magnitude of the correlation coefficient supports the traditional farm management cross tabulation analysis that this is an important business factor.

Herd size as measured by number of cows, is a commonly used management factor. It is easy to ascertain and does indicate the number of production units in the business. The correlation coefficient for number of cows and operator income was .238. This is somewhat lower than the three previous measures discussed but is still a relatively high coefficient recognizing the many different things which have an effect on the final result of labor and management income.

Pounds of concentrate fed per cow is a measure from the DHI data. This measures the average level of concentrate feeding in the herds. The feeding practice in turn effects the rate of production per cow which was observed to be an important factor in the table. The correlation coefficient for pounds of concentrate fed per cow and income was .198. This indicated that rates of concentrate feeding does have a positive effect on the operator's income. New York dairymen, on the average, were being more than compensated for their increased amounts of concentrates fed per cow in 1974.

From the DHIA information on breeding practices, days dry, and pounds of concentrates per cow showed the largest correlation coefficient with operator income. Days dry is the more obvious; if a cow is not milking, she is dry, if she is dry no milk is sold from her and no income is realized.

Table 1. CORRELATION COEFFICIENTS FOR SELECTED DAIRY PRACTICE FACTORS WITH LABOR AND MANAGEMENT INCOME PER OPERATOR
413 New York Dairy Farms, 1974

Variables	Labor and Management Income Per Operator Correlation Coefficient
Negative Correlations:	
Cost of producing hundredweight milk	-.820
Feed and crop expense per hundredweight milk	-.299
Days dry	-.225
Investment per cow	-.217
Net energy from pasture	-.197
Debt per cow	-.170
Machinery expense per cow	-.155
Net energy from hay	-.137
Labor per cow	-.122
Calving interval	-.122
Feed costs per cow	-.108
Net energy from concentrates	-.082
Percent leaving herd	-.051*
Positive Correlations:	
Pounds milk sold per man	.367
Pounds milk sold per cow	.358
Total pounds milk sold	.340
Herd size (number cows)	.238
Pounds concentrate per cow	.198
Bodyweight	.187
Percent days in milk	.171
Man equivalents	.148
Percent equity	.138
Total farm inventory	.126
Percent new energy from silages	.103
Total investment per man	.042*

* Not significant at .05 level.

The data in table 2 are taken from 615 New York dairy farms. The data used in this study are a subfile of the original 628 farms. Thirteen farms were eliminated for lack of specific information.

Correlation coefficients for selected variables with operator income by two different barn types are shown in table 2. The largest correlation difference between barn types is herd size (.134 and .240). Part of this difference is due to the association of free stall barns and increasing cow numbers. Free stall operators were associated with expanding cow numbers and generally larger herds. The coefficient (.240) reflects this relationship.

Milk sold per man shows a slightly higher correlation in stanchion barns. This small difference illustrates the economic importance of increased efficiency and productivity needed in stanchion barns. Pounds of milk sold per cow and total investment per cow show nearly identical correlation coefficients in these data. The relationship between productivity per cow and capital investment per cow is similar for either barn type in 1974.

Table 2. CORRELATION OF SELECTED BUSINESS MANAGEMENT FACTORS WITH LABOR AND MANAGEMENT INCOME PER OPERATOR
615 New York Dairy Farms, 1974

Item or Variables	Barn Type: Stanchion	Barn Type: Free Stall
Number of farms	414	201
Percent of farms	67.3%	32.7%
	Correlation Coefficients*	
Pounds milk sold per cow	.343	.344
Pounds milk sold per man	.329	.280
Herd size (number of cows)	.134	.240
Total investment per cow	-.217	-.219

* Simple correlation of variable with labor and management income per operator.

Size Factors

Size factors have been shown to be closely associated with income.[1] Cross tabulation analysis on FBR data has shown size to be a major factor affecting income on New York dairy farms.[2] Correlations by various measures of size are shown in table 3.

Herd size shows definite relationships with total pounds milk sold annually and total farm inventory. These coefficients are expected because all are size measurements. Man equivalent is also a size measure that correlates strongly with all the above mentioned variables.

Milk sold per man is a measure of efficiency and productivity. This variable shows considerable correlation with the size measurements. As the farm size increases, productivity and efficiency generally increase as well.

1. E. L. LaDue and C. A. Bratton. "Factors Affecting Incomes, New York Dairy Farms, 1966," A.E. Res. 229, Department of Agricultural Economics, New York State College of Agriculture and Life Sciences, Cornell University, August 1967.

2. C. A. Bratton, "Dairy Farm Management Business Summary," A.E. Res. 75-7, Department of Agricultural Economics, New York State College of Agriculture and Life Sciences, Cornell University, June 1975.

Milk sold per cow shows little or no correlation with inventory, herd size, or man equivalents. This indicates size factors have little effect on milk productivity per unit. Some have hypothesized that farms with larger herds suffer from lower milk production per cow. The correlation shows size and milk production per cow are generally not related.

Table 3. CORRELATION OF VARIABLES RELATING TO SIZE OF OPERATION
413 New York Dairy Farms, 1974

Variables	Total Farm Inventory	Herd Size	Man Equivalents	Total Pounds Milk Sold Annually
Herd size (number of cows)	.845	1.00	.872	.955
Man equivalents	.770	.872	1.00	.837
Investment per man	.471	.129	-.132	.140
Average milk price	.240	.215	.267	.171
Milk sold per man	.363	.430	.046*	.541
Milk sold per cow	.13	0.07*	.102	.316

* Not significantly different from zero at .05 level.

Milk sold per cow has been an important factor affecting labor and management income as shown both in cross tabulation and in correlation analysis. The correlation with several management variables is shown in table 4.

Pounds of concentrates fed per cow had the highest correlation (.541) with milk sold per cow. This emphasizes the importance of grain feeding to get high rates of production. Bodyweight had the second highest correlation coefficient, .485, with milk sold per cow. This suggests that the larger cows were generally better producers. Size of animals would appear to be an important dairy management factor.

Milk sold per man is another dairy management practice that relates closely with profitability (table 1). In table 4, this variable shows strong association with total pounds of milk sold annually and milk sold per cow. Farms showing increased milk per cow also showed increases in milk sold per man (+.45).

One of the most important cost factors, cost of producing a hundredweight of milk, showed a strong -.427 coefficient with milk sold per man. This is an important management and cost control tool. As labor efficiency increases, cost per unit decreases. The correlation of labor costs per cow and milk sold per man (-.601) further verifies this relationship.

Table 4. CORRELATION OF PRODUCTIVITY AND LABOR EFFICIENCY
WITH SELECTED VARIABLES
413 New York Dairy Farms, 1974

Variables	Milk Sold Per Cow	Milk Sold Per Man	Labor Costs Per Cow
Milk sold per man	.450	1.00	-.601
Milk sold per cow	1.00	.450	.176
Percent days in milk	.339	.290	-.027*
Pounds concentrate per cow	.541	.208	.195
Days dry	-.308	-.265	.046*
Bodyweight	.485	.248	.131
Cost of producing hundredweight milk	-.424	-.427	.232
Total pounds milk sold annually	.316	.540	-.118
Investment per cow	.156	-.140	.176

* Not significantly different from zero at .05 level.

Cost Control

Correlation coefficients for factors related to feed, machinery, capital and debt are listed in table 5. Feed is the largest single cost item on a dairy farm. Two feed cost control measures were included in the data: purchased feed cost per cow, and feed costs per hundredweight of milk sold. The correlation coefficient for feed cost per hundredweight of milk sold and income was -.299. This suggests that the greater the feed costs per hundredweight of milk, the smaller the income. The size of the coefficient also indicates its importance. The coefficient for purchased feed cost per cow and operator income was smaller (-.108). This was expected since the purchased feed is only a part of the total feed costs.

The relationship between purchased feed cost per cow and feed cost per hundredweight of milk was high (.781). Purchased feed is a major component of the total feed costs on many of the farms in this study. Similarly, there was a high correlation (.341) between pounds of concentrate fed per cow and purchased feed cost per cow. There was no significant relationship between the feed cost measures and pounds of milk sold per cow. This is revealing since it might logically be expected that higher feed costs would result in more milk.

In 1974, the total investments calculated on a per cow basis was overall inefficient and unproductive. The -.217 correlation with operator income indicates this association. Increased investment on a per cow basis should either reduce the unit costs of the farm operation (efficiency) or increase the output (productivity). If additional investment does not accomplish either or both of these ends, it will most certainly affect profitability.

Herd size shows a -.216 correlation with investment per cow. As the average number of cows increases, investment per cow becomes more efficient. The effect of size on efficiency is apparent in the sample 413 farms. Increased herd size is also associated with decreasing machinery costs per cow (-.191) and decreasing cost of producing a hundredweight of milk (-.169).

Percent days in milk and days dry show very little correlation with any of the cost or investment variables. This would suggest dairy management decisions are made separately and show no consistency with cost control and investment decisions.

Milk price follows a similar pattern. It is not closely associated with the cost control or investment practices of the dairy farm. Milk price and investment per cow show no significant association. Debt per cow also shows no correlation with milk price.

Table 5. CORRELATION OF COST CONTROL VARIABLES WITH SELECTED BUSINESS MANAGEMENT VARIABLES 413 New York Dairy Farms, 1974

Variables	Cost of Producing a hundredweight of milk	Feed Costs Per hundredweight of milk	Feed Costs Per Cow	Investment Per Cow	Debt Per Cow	Machinery Costs Per Cow
Labor and management income per operator	-.82	-.299	-.108	-.217	-.170	-.155
Herd size	-.169	.086	-.109	-.216	-.056*	-.191
Milk sold per cow	-.424	.040*	.038*	.156	-.144	.127
Milk sold per man	-.427	.015*	.427	-.151	-.029*	-.100
Feed costs per hundredweight of milk	.342	1.00	.781	-.051*	-.022	-.139
Percent days in milk	-.109	.005*	.092	.089	-.040*	.154
Pounds of concentrate per cow	-.172	.154	.341	.137	.005*	.053*
Days dry	.192	.066*	-.041	-.007*	.124	-.083*
Milk price	.217	.167	.045*	.067*	-.005*	.061*

* Not significantly different from zero at .05 level.

Dairy Management Practices

One purpose for undertaking this study was to compare and quantify the relationships between FBR and DHIA variables. Tables 6 and 7 list the correlation coefficients of dairy management practices and feeding practices as measured by the DHIA system with selected FBR variables.

Days dry and percent days in milk show a good correlation with milk per cow and milk per man. This is expected. The relationship with operator income is slightly less, but still significant. These two dairy management variables are important indicators for the manager in measuring performance.

Heavier cows were producing more milk and utilizing labor more efficiently (milk per man). They also consumed more concentrate and were generally associated with larger size operations (total pounds of milk sold annually).

Pounds of concentrates per cow and percent days in milk have an indirect correlation. That is, they are both highly correlated to milk sold per cow. Pounds of concentrates increased as bodyweight increased (.257).

Breeding per conception is a breeding efficiency measure used by DHI. Factors influencing this variable are heat detection, reproductive health, expertise of inseminator, and production of the animal. This variable shows a .298 correlation with total pounds of milk sold annually, a size measure. This means the larger herds in the sample were using more breedings per conception and were less effective in their breeding programs than smaller herd sizes. Average calving interval generally shows smaller correlation coefficients with the management variable than percent days in milk or days dry. Average calving interval is unprofitable when it becomes excessively long.

Table 6. CORRELATION OF VARIABLES RELATING TO DAIRY MANAGEMENT PRACTICES
413 New York Dairy Farms, 1974

Variables	Days Dry	Percent Days in Milk	Average Calving Interval	Breedings Per Conception	Bodyweight	Test
Labor and management income per operator	-.225	.171	-.127	-.019*	.188	-.039*
Man equivalents	-.094	.107	-.042*	.128	.053*	.222
Milk sold per cow	-.308	.339	.011*	.126	.485	-.169
Milk sold per man	-.265	.290	-.027*	-.005*	.248	-.091
Feed costs per hundredweight of milk	.066*	.005*	.124	.100	.160	-.073*
Pounds of concentrate per cow	-.131	.206	.013	.173	.257	-.090
Cost of producing a hundredweight of milk	.192	-.109	.102	-.172	-.236	.184
Total pounds milk sold annually	-.213	.230	-.074*	.298	.184	.125

* Not significantly different from zero at .05 level.

DHIA Feeding Practices

The specific feeding measures of the DHIA information and their correlations with selected FBR variables are shown in table 7. The percent net energy variables estimate the portion of net energy represented in the total ration from each of the four feeding areas. Pounds of concentrates measures the concentrates fed per cow per year.

Pounds of concentrates fed and milk sold per cow show a strong .541 correlation. Increased amounts of concentrates show positive effect on milk production. Increased concentrate feeding was further associated with decreases in cost of producing a hundredweight of milk (-.172). In 1974, increased concentrate feeding showed positive correlations with productivity and profitability measures.

Net energy from pasture estimates the amount of pasture grazing in the ration. This variable showed a comparatively strong correlation with decreasing income in 1974. In fact, net energy from pasture shows significant negative correlation with many of the productivity variables in table 7.

Net energy from hay shows a strong negative correlation with herd size. This variable is similar to percent net energy from pasture. Farmers employing either increased amounts of pasture or hay had negative correlations with both milk sold per man and milk sold per cow in 1974.

Investment per man showed -.233 correlation with net energy from hay and .987 correlation with net energy from silage. Farms using large amounts of silage observed increasing efficiency of investments on a per man basis while those farms using large amounts of hay in the ration observed decreasing investment efficiency.

Table 7. CORRELATION OF FEEDING PRACTICES WITH SELECTED VARIABLES
413 New York Dairy Farms, 1974

Variables	Pounds of Concentrates Fed Per Cow	Percent Net Energy From: Concentrates	Silages	Hay	Pasture
Labor and management income per operator	.196	-.082	.103	.137	-.197
Herd size	.175	-.084	.387	-.387	-.333
Milk sold per cow	.541	.061*	.013*	-.131	-.221
Milk sold per man	.208	-.076*	.251	-.297	-.248
Feed costs per cow	.341	.146	-.184	.024*	-.013*
Machinery costs per cow	.053*	-.009*	.038*	-.063	-.012*
Labor per cow	.195	.092	-.131	.074*	.050*
Investment per man	.036*	.006*	.187	-.233	-.065*
Investment per cow	.137	.099	-.024*	-.057*	.060*
Cost of producing a hundredweight of milk	-.172	.074*	-.058*	.050*	.188

*Not significantly different from zero at .05 level.

Herd size shows a similar reciprocal relationship between these two feeding variables. Silage systems were associated with increasing cow numbers (.387) while hay systems were associated with decreasing cow numbers (-.387). Larger herds generally lend themselves more readily to succulent feeding systems as measured by percent net nergy from silages, while smaller herds generally use more dry hay in the ration.

Productivity as measured by milk sold per man shows contrasting correlation coefficients between net energy from silages and net energy from hay. Increases in productivity were associated with silage systems whereas decreases in productivity were associated with dry hay feeding.

Partial Correlation Analysis

Simple correlation measures the relationship between two variables and it is assumed all extraneous factors are held constant. In the dynamic farm situation, simple correlation is limited in its usefulness. Many different interactions among variables exist which inhibit the simple correlation interpretation.

Partial correlation analysis is an extension of simple correlation and will aid in the understanding of these relationships, especially where numerous interactions are involved. Partial correlation is a single measure of association describing the relationship between two variables while adjusting for the effects of one or more additional variables.

Conceptually, partial correlation is similar to cross tabulation with control variables. In cross tabulation, the control is literal, i.e., one simultaneously locates each observation according to the value it takes in three or more variables. In partial correlation, the control is statistical rather than literal. It is based on the simplifying assumption of linear relationships among the variables. It allows one to remove the effect of the control variable from the relationship without physically manipulating the data.[1] Partial correlation analysis is useful in developing an understanding of multiple variable effects on correlation coefficients.

In the first column of table 8, four simple bivariate correlations with labor and management income are listed. The first correlation is operator income with herd size. The simple coefficient is .259. When the effects of pounds of milk sold per man are adjusted (see column headings), the coefficient drops to a small .069. Several explanations can be put forth to describe this decline. Milk per man is significantly correlated with both variables. When its effects are held constant, the bivariate relationship diminishes.

A similar situation exists between operator income and milk sold per cow. The simple correlation coefficient is .360 but raises to .408 when investment per cow effects are held constant.

1. N. H. Nie and Associates, Statistical Package for the Social Sciences, Second Edition, McGraw-Hill, Inc., 1975. p. 302.

The above two examples of changing correlation coefficients were related to operator income. Further partial correlation analysis revealed much variation in coefficients, but will not be described here. It is sufficient to conclude that operator income is determined through the combined interaction of many factors. Under partial correlation analysis operator income showed large variation in the magnitude of its correlation with DHI and FBR variables.

Table 9 lists selected simple and first order partial correlations with milk sold per man. Milk sold per man is an economic and efficiency measure, which is relevant to management decisions. The coefficient between milk sold per man and investment per man is .580. When the effects of investment per cow are held constant, the correlation rises to .853. Again variables and external interaction is apparent in the interpretation.

The partial correlation analysis presented in tables 8 and 9 is brief. It is not intended to isolate all variable interactions but merely to establish that many of the relationships are not independent, as simple correlation analysis assumes. The magnitude of any simple correlation relationship is subject to much variability. Further refinement of the management measures is needed to account for the specific independent activities involved in the farm management process.

Table 8. CORRELATION OF SELECTED BUSINESS MANAGEMENT FACTORS WITH LABOR AND MANAGEMENT INCOME PER OPERATOR
628 New York Dairy Farms, 1974

		First Order Correlations Controlling For:					
	Simple Correlation	Feed Costs as Percent of Milk Sold	Pounds Milk Sold Per Cow	Herd Size (Cows)	Investment Per Cow	Pounds Milk Sold Per Man	Investment Per Man
Labor and management income per operator with herd size							
Correlation	.259	.239	.187	--	.232	.069	.278
Significance	.001	.001	.001	--	.001	.080	.001
Labor and management income per operator with pounds milk sold per cow							
Correlation	.360	.361	--	.316	.408	.218	.369
Significance	.001	.001	--	.001	.001	.001	.001
Labor and management income per operator with pounds milk sold per man							
Correlation	.348	.353	.194	.249	.335	--	.444
Significance	.001	.001	.001	.001	.001	--	.001
Labor and management income per operator with investment per cow							
Correlation	-.205	-.251	-.288	-.169	--	-.181	-.248
Significance	.001	.001	.001	.001	--	.001	.001

Table 9. CORRELATION OF SELECTED BUSINESS MANAGEMENT FACTORS WITH POUNDS OF MILK SOLD PER MAN
628 New York Dairy Farms, 1974

		First Order Correlations Controlling For:					
	Simple Corre-lation	Feed Costs as Percent of Milk Sold	Pounds Milk Sold Per Cow	Herd Size (Cows)	Invest-ment Per Cow	Labor and Management Income Per Operator	Invest-ment Per Man
Pounds milk sold per man with herd size							
Correlation	.595	--	.565	--	.589	.558	.546
Significance	.001	--	.001	--	.001	.001	.001
Pounds milk sold per man with labor and management income per operator							
Correlation	.348	.353	.194	.249	.335	--	.444
Significance	.001	.001	.001	.001	.001	--	.001
Pounds milk sold per man with investment per cow							
Correlation	-.10	--	-.234	-.004	--	-.036	-.77
Significance	.009	--	.001	.90	--	.36	.001
Pounds milk sold per man with investment per man							
Correlation	.580	.579	.594	.527	.853	.627	--
Significance	.001	.001	.001	.001	.001	.001	--

Selected Correlations by Herd Sizes

The purpose of the tables in this section is to observe the change in correlation coefficients among different FBR herd size groupings. As mentioned previously, the 413 sample dairy farms represent a broad spectrum of dairy farm systems and dairy management practices which is affirmed in the side variation of the coefficients.

The correlation of operator income and pounds of milk sold per man is .367 for the average farm in the sample (table 1). This same correlation is shown in table 10 by seven different herd sizes. The range in the coefficient is from .141 to .421. The larger herds tend to show a stronger correlation. Moving from small to larger herds, the coefficient generally increases. Efficiency, as measured by pounds of milk sold per man is more closely associated with profitability as dairy farms become larger.

Milk sold per cow and income also show a general increasing coefficient by herd size groupings. Production (milk sold per cow) is important to profitability especially in the larger herds where total economic risk is greater.

Investment per cow has the largest negative correlation with income in the smallest herd size grouping. This coefficient becomes smaller and loses significance in the 85-99 herd size group. Heavy investment per cow is related with lower profitability in the smaller herd sizes. This relationship becomes less important as herd size increases.

Table 10. CORRELATION OF PRODUCTIVITY AND INVESTMENT WITH LABOR AND MANAGEMENT INCOME PER OPERATOR BY HERD SIZE
413 New York Dairy Farms, 1974

Herd Size (Cows)	Number of Herds	Percent of Total	Labor and Management Income Correlated With: Pounds Milk Sold		Investment	
			Per Man	Per Cow	Per Man	Per Cow
Under 40	41	10	.275	.224	-.238	-.406
40 to 54	119	29	.257	.289	.183	-.340
55 to 69	91	22	.296	.447	-.174	-.198
70 to 84	48	12	.421	.389	.033*	-.182
85 to 99	30	7	.141*	.434	.110*	.169
100 to 149	60	14	.326	.425	.023*	.023*
150 & over	24	6	.410	.342	-.116*	-.247*

* Not significantly different from zero correlation at .10 level.

Cost Control by Herd Size

Cost control is a key dairy management factor. Table 11 lists correlations of selected cost control variables by herd size. These cost control variables are actually ratios of costs on a per man or per cow basis.

Cost of producing a hundredweight of milk correlated with milk sold per cow shows a strong positive relationship with all seven herd size groups. Pounds of milk sold per man and the cost of producing a hundredweight of milk show a general increasing correlation coefficient for increasing herd size. As increased productivity is achieved, total costs are spread among more units and the correlation becomes greater. The one exception to this increasing correlation relationship is the 85-99 herd size group. This group of farmers has very low income and very high costs. Interpretation within this group is difficult because of its gross difference from the sample mean. Further clarifying information is needed for this group.

About half of the correlations under labor costs, feed costs and debt per cow are small or insignificant. It is believed that much of the variation in these variables is from different herd sizes. When these effects are diminished through cross tabulation, the remaining correlations are small. This leads to the conclusion that herd size has a significant association with many of the dairy management variables and when its effects are controlled many of the variable relationships diminish significantly.

Table 11. CORRELATION OF COST CONTROL WITH RELATED FACTORS BY HERD SIZE
413 New York Dairy Farms, 1974

Herd Size (Cows)	Cost of Producing a Hundredweight of Milk: Milk Sold Per Cow	Cost of Producing a Hundredweight of Milk: Milk Sold Per Man	Operator Income and: Labor Costs Per Cow	Operator Income and: Feed Costs Per Cow	Operator Income and: Debt Per Cow
Under 40	-.201	-.362	-.183*	-.327	-.172*
40 to 54	-.355	-.353	-.103*	-.033*	-.117
55 to 69	-.539	-.411	-.008*	-.058*	-.163
70 to 84	-.471	-.442	-.208	-.035*	-.352
85 to 99	-.496	-.152*	-.232	-.347	.078*
100 to 149	-.486	-.493	-.064*	-.128*	-.008*
150 & over	-.419	-.500	-.218*	-.290	-.578

* Not significantly different from zero correlation at .10 level.

Dairy Management Practices by Herd Size

Table 12 lists selected dairy management correlations by herd size. Each correlation in this table involves a FBR variable correlated with a DHIA variable. This shows interrelationships between the two information systems.

The correlation of average days dry and operator income is -.225 for the average herd (see appendix table). However, this same correlation shows much variation by representative herd size groupings. The range is from -.002 to -.655. The association of days dry and operator income has extremely wide variation in the 1974 data. Percent days in milk and operator income show a similar, but weaker, relationship. In the small herd sizes, percent days in milk has little association with income.

Breeding per conception and milk sold per cow show no strong trends among herd sizes. The positive coefficient is in agreement with the theory of higher producing cows generally having lower conception rates.

Pounds of concentrate and milk sold per cow show the lowest correlation coefficient in the over 150 herd size group. Previous cross tabulation has shown this group to be feeding large amounts of concentrates. Any increases in amounts of concentrates above the present level are observed to have less marginal effect on milk production than increases at lower herd levels. Bodyweight and income remain reasonably constant through all herd sizes. This relationship is indirect in that additional bodyweight correlated with more milk sold per cow, which is positively correlated with income.

Table 12. CORRELATION OF DAIRY MANAGEMENT BY HERD SIZE
413 New York Dairy Farms, 1974

Herd Size (Cows)	Operator Income and: Average Days Dry	Operator Income and: Percent Days in Milk	Breedings Per Conception and Milk Sold Per Cow	Pounds of Concentrate Fed Per Cow and Milk Sold Per Cow	Bodyweight and Operator Income
Under 40	-.096*	-.162*	.120*	.585	.177
40 to 54	-.002*	-.045*	.173	.580	.183
55 to 69	-.240	.223	.188	.577	.162
70 to 84	-.283	.263	.006*	.580	.124*
85 to 99	.141*	-.186*	.264	.440	.254
100 to 149	-.269	.260	-.133*	.512	.155*
150 & over	-.655	.540	.121*	.330	.283

* Not significantly different from zero correlation at .10 level.

Feeding Practices by Herd Size

Table 13 shows some interesting correlations of feeding practices as measured by DHI and income as measured by the FBR system. For each herd size, percent net energy from silages and dry hay correlated with operator income in opposite directions. The smallest farms show positive income associated with silage feeding and negative income associated with hay feeding. The largest farms, in contrast, show an insignificant relationship between percent net energy from silages and operator income, but a relatively large negative correlation between net energy from hay and operator income.

These coefficient relationships reflect the management situations involved in feeding. The large herd size farms generally do not feed dry hay as a large proportion of the total ration (-.493). The cross tabulation of these large farms showed most relying upon succulent systems and the correlation analysis here agrees with the finding. As a group, dairy farmers using increased amounts of pasture in the feeding programs are not very successful managers, regardless of herd size. The coefficients show a consistent negative relationship with operator income. Many of the farms utilizing the greatest amounts of pasture appear to be marginal farms and reflect a definite economic problem. More information is needed about these particular farms feeding great amounts of pasture.

Table 13. CORRELATION OF FEEDING PRACTICES AND LABOR AND MANAGEMENT INCOME PER OPERATOR BY HERD SIZE
413 New York Dairy Farms, 1974

Herd Size (Cows)	Labor and Management Income Per Operator Correlated With: Percent Net Energy from Silage	Percent Net Energy from Hay	Percent Net Energy from Pasture
Under 40	.464	-.250	-.312
40 to 54	-.198	.163	-.050*
55 to 69	.135*	-.105*	-.203
70 to 84	.132*	-.151*	-.229*
85 to 99	.222*	-.178*	-.122*
100 to 149	.027*	-.207	-.235
150 & over	.068*	-.493	-.275*

* Not significantly different from a zero correlation at .10 level.

Selected Correlations by Income Groupings

The last section of correlation tables will focus attention on coefficients among seven income levels. The income groups, like the previous herd sizes, correspond with the annual farm business summary cross tabulations. The purpose of this section is to observe selected correlation relationships among different levels of labor and management income per operator, a primary production goal.

Table 14 shows the same correlations as table 10, using income level rather than herd size in cross tabulation. Many of the significant correlations lose meaning when income variance is partially controlled by cross tabulation. The productivity factors, milk per man and milk per cow, generally do not vary much with operator income within the income groups, therefore, the correlation coefficient with income is small within each group (table 14).

Investment per man and investment per cow also show small correlation with operator income for the seven income groups because much of the variance has been removed by the income cross tabulation.

Table 14. CORRELATION OF PRODUCTIVITY AND INVESTMENT FACTORS WITH LABOR AND MANAGEMENT INCOME PER OPERATOR BY INCOME LEVEL
413 New York Dairy Farms, 1974

			Labor and Management Income Correlated With:			
Income Level	Number of Farms	Percent of Total	Pounds Milk Sold Per Man	Pounds Milk Sold Per Cow	Investment Per Man	Investment Per Cow
Under -$4,999	75	18%	-.015*	.130	-.058*	-.028*
-$4,999 to -$1	62	15	.144*	-.134*	.088*	-.145*
$0 to $4,999	75	18	.050*	-.129*	.025*	-.069*
$5,000 to $9,999	83	20	.221	.300	.095*	.020*
$10,000 to $14,999	57	14	-.046*	.052*	-.155*	-.102*
$15,000 to $19,999	30	7	.427	.249	.118*	-.241
$20,000 and over	31	8	.157*	.158*	.062*	.033*

* Not significantly different from zero correlation at .10 level.

Cost Control by Income Level

Selected cost control correlations by income level are shown in table 15. Milk sold per cow and cost of producing a hundredweight of milk show a general decreasing importance as income level increases. For negative income groups, milk production per cow and cost of producing a hundredweight of milk are significantly correlated, but larger income levels show this relationship to be much less important.

Milk sold per man and cost of producing a hundredweight of milk have an interesting coefficient progression from negative to positive for increasing income levels. For lower or negative income farms, increasing milk sold per man show a strong association with reducing milk production costs. In contrast, higher income groups show a positive correlation between costs per hundredweight and milk sold per man. As income level increases, milk sold per man is less associated with milk production costs. Total milk production costs are spread over more units of milk due to the fact that larger farms generally comprise the higher income levels.

Labor costs, feed costs and debt show separate relationships among income levels. Again, several other unspecified factors are clouding the correlations.

Table 15. CORRELATION OF COST CONTROL BY INCOME LEVEL
413 New York Dairy Farms, 1974

Income Level	Cost of Producing a Hundredweight of Milk and Milk Sold: Per Cow	Per Man	Labor Costs Per Cow and Operator Income	Feed Costs Per Cow and Operator Income	Debt Per Cow and Operator Income
Under -$4,999	-.533	-.596	.024*	.015*	.051*
-$4,999 to -$1	-.163	-.537	-.204	-.199	-.239
$0 to $4,999	-.098*	-.285	-.025*	-.066*	-.202
$5,000 to $9,999	-.094*	-.131*	-.007*	.161	-.003*
$10,000 to $14,999	-.002*	.007*	.062*	.122*	-.108*
$15,000 to $19,999	.106*	.278	-.245	.235	-.465
$20,000 and over	-.098*	.255	.129*	-.146*	-.058*

* Not significantly different from zero correlation at .10 level.

Dairy Management Practice by Income Level

Correlation coefficients of selected dairy management practices by income level are listed in table 16. Pounds of concentrate fed per cow and milk sold per cow show an interesting coefficient pattern among income levels. For each income level, the coefficient decreases. The range is from .637 in the lowest income group to -.045 in the highest group. This progression shows a definite association between grain feeding levels and milk sold per cow for increasing levels of operator income. The lowest income group could benefit the most by re-evaluating their grain feeding programs.

Breedings per conception is generally associated with increased amounts of milk sold per cow. Percent days in milk and days dry show little direct correlation with herd size within income groups.

Table 16. CORRELATION OF DAIRY MANAGEMENT BY INCOME LEVEL
413 New York Dairy Farms, 1974

Income Level	Herd Size and: Average Days Dry	Percent Days in Milk	Milk Sold Per Cow: Breedings Per Conception	Pounds of Concentrate Fed Per Cow
Under -$4,999	.110*	-.011*	.202	.637
-$4,999 to -$1	-.187	.092*	.059*	.586
$0 to $4,999	-.103*	.132*	.078*	.632
$5,000 to $9,999	-.021*	.112*	.334	.522
$10,000 to $14,999	-.090*	.059*	-.104*	.420
$15,000 to $19,999	-.375	.382	.324	.250
$20,000 and over	.111*	-.149*	.209*	-.045*

* Not significantly different from zero correlation at .10 level.

Feeding Practices by Income Level

The correlations among different feeding systems and herd size for seven income levels are shown in table 17. This table shows the association of feeding systems as measured by net energy levels among different income groups.

Herd size and percent net energy from silages show generally positive significant coefficients for all income levels. The larger farms were using more succulents in the ration. The sixth income group ($15,000 to $19,999) shows a .643 correlation between these two variables.

Conversely, hay feeding systems were associated with decreasing cow numbers among the income levels. In the 1974 data, dry hay feeding is generally limited to small dairy operations.

Pasture feeding shows consistent negative correlations with herd size. The coefficients range from -.214 to -.652. Similar to hay, pasture feeding systems were associated with smaller farms in 1974.

Table 17. CORRELATION OF FEEDING PRACTICES WITH HERD SIZE BY INCOME LEVELS
413 New York Dairy Farms, 1974

Income Level	Herd Size (Number of Cows) Correlated With Percent Net Energy From: Silages	Hay	Pasture
Under -$4,999	.500	-.371	-.371
-$4,999 to -$1	.381	-.213	-.344
$0 to $4,999	.356	-.369	-.298
$5,000 to $9,999	.359	-.368	-.317
$10,000 to $14,999	.297	-.449	-.214
$15,000 to $19,999	.643	-.614	-.652
$20,000 and over	.149*	-.395	-.442

* Not significantly different from zero correlation at .10 level.

Summary and Conclusions

This publication brings together information from the farm business records (FBR) and the dairy herd improvement (DHI) information systems for the purpose of quantifying, through correlation analysis, the relationship of various management factors. Information used in this study was obtained from 413 New York dairy farms enrolled in both FBR projects and members of the DHIA organization.

Simple correlation and partial correlation (first order) have been used to quantify the general relationships. A matrix of 40 variables correlated is found in the appendix. The most important correlations of this appendix table are discussed in the main body of the presentation. Correlation coefficients were also reported on seven herd size and seven income level groupings of the 413 farms.

Size is the largest factor influencing the magnitude of the correlation coefficients. As farms increase cow numbers and sell more pounds of milk many of the variables change in a size dependent relationship. Variables that measure productivity, efficiency, cost control, capital investment efficiency, and profitability generally show positive correlations with size variables.

Both breeding and feeding practices show a general relationship with increases in productivity, which is related to income increases. Days dry, percent net energy from silages, and bodyweight are three DHI variables that correlate significantly with operator income. Pounds of concentrates showed a positive correlation with both milk sold per cow and operator income.

Capital investment per man and per cow show negative correlations with labor and management income, suggesting the sample farms need to use discretion in their investment decisions.

The cost variables show negative correlation with operator income. Labor per cow in particular showed a negative correlation suggesting better labor management practices are needed in the study farms.

This study was limited to observations and information collected in 1974. Many random effects are present distorting the true long-term association of the management factors. A time series study covering several years would minimize the random effects and bring to the surface the important management factors and their refined association with labor and management income per operator.

APPENDIX

Table A1. Correlations of Farm Business Records and Dairy Herd Improvement Variable; 413 New York Dairy Farms, 1974.

	Feed & supply inven-tory	Total farm inven-tory	Annual concen-trate expend-iture	Labor & manage-ment in-come per operator	Percent equity	Debt per cow	Herd size	Man equiv-alents	Milk sold per cow	Milk sold per man	Pur-chased feed costs per cow	Pur-chased feed costs per cwt./milk
Feed and supply inventory	1.00	.769	.560	.384	.011[a]	.043[a]	.737	.687	.193	.323	-.049[a]	.018[a]
Total farm inventory		1.00	.697	.126	-.018[a]	.150	.845	.770	.134	.363	.006[a]	.048[a]
Annual concen-trate expenditure			1.00	.126	.052[a]	.105	.842	.737	.271	.475	.516	.443
Labor & management income per operator				1.00	.138	-.170	.238	.148	.377	.367	-.108	-.299
Percent equity					1.00	-.876	.001[a]	.072[a]	.245	.002[a]	.080[a]	.030[a]
Debt per cow						1.00	-.056[a]	-.080	-.144	-.029[a]	-.109	-.022[a]
Herd size							1.00	.872	.070[a]	.430	.034[a]	.086
Man equivalents								1.00	.102	.046[a]	.038[a]	.080
Milk sold per cow									1.00	.450	.427	.040[a]
Milk sold per man										1.00	.212	.015[a]
Purchased feed costs per cow											1.00	.781
Purchased feed costs per cwt./milk												1.00

Table A1 (cont'd.)

	Machinery cost per cow	Labor per cow	Investment per man	Investment per cow	Percent days in milk	Test	Lbs. concentrate cow /yr.	Percent net energy concentrates	Percent net energy silages	Percent net energy hay	Percent net energy pasture	Avg. calving interval
Feed and supply inventory	.042[a]	-.017[a]	.221	.036[a]	.198	.174	.292	-.101	.388	-.417	-.421	-.0414[a]
Total farm inventory	-.0162[a]	-.070[a]	.471	.272	.196	.189	.236	-.023[a]	.370	-.400	-.313	.006[a]
Annual concentrate expenditure	-.238	-.120	.085	-.208	.154	.132	.300	.009[a]	.270	-.324	-.305	-.020[a]
Labor & management income per operator	-.155	-.122	-.042[a]	-.217	.171	-.039[a]	.196	-.082	.103	.137	-.197	-.127
Percent equity	.020[a]	.224	-.136	-.005[a]	.154	.045[a]	.042[a]	-.070[a]	-.060[a]	-.003[a]	.133	.025[a]
Debt per cow	.162	-.104	.370	.385	-.040[a]	-.007	.005[a]	.087	.090[a]	-.034[a]	-.122	.010[a]
Herd size	-.191	-.172	.129	-.216	.157	.199	.175	-.084	.387	-.387	-.333	-.080[a]
Man equivalents	-.120	.213	-.132	-.114	.107	.222	.226	-.029[a]	.297	-.296	-.296	-.042[a]
Milk sold per cow	.127	.176	.052[a]	.156	.339	-.541	.061[a]	.061[a]	.013[a]	-.131	-.221	.011[a]
Milk sold per man	-.100	-.601	.533	-.151	.290	-.091	.208	-.076[a]	.251	-.297	-.248	-.027[a]
Purchased feed costs per cow	-.175	.035[a]	-.046[a]	-.044[a]	.092	-.073[a]	.341	.146	-.184	.024[a]	-.013[a]	.090
Purchased feed costs per cwt. /milk	-.139	-.042[a]	-.013[a]	-.051[a]	.005[a]	.1222	.154	.061[a]	-.046	-.041[a]	-.053[a]	.124

Table 1A (cont'd.)

	Days dry	Breedings per conception	Percent leaving herd	Body-weight	Average milk price	Yield of corn per acre	Yield of hay per acre	Cost of producing cwt. milk	Total pound milk sold annually	Dairy concen-trate price
Feed and supply inventory	-.179	.128	.025[a]	.164	.194	.171	.297	-.262	.756	-.240
Total farm inventory	-.143	.108	.013[a]	.136	.240	.142	.217	-.043[a]	.828	-.140
Annual concen-trate expendi-ture	-.123	.116	.015[a]	.127	.215	.090	.087	-.097	.873	.257
Labor & manage-ment income per operator	-.225	-.019[a]	-.051[a]	.188	.029[a]	.153	.202	-.820	.340	-.249
Percent equity	-.177	.007[a]	.022[a]	.079[a]	.098	.162	.109	-.088	.071[a]	.069[a]
Debt per cow	.124	.001[a]	.004[a]	-.007[a]	-.005[a]	-.121	-.078[a]	.170	-.095	-.106
Herd size	-.142	.076	-.023[a]	.053[a]	.215	.131	.183	-.169	.955	-.092
Man equivalents	-.094	.128	-.029[a]	.053[a]	.267	.137	.115	-.061[a]	.837	-.114
Milk sold per cow	-.308	.126	.010[a]	.485	-.064[a]	.092	.091	-.424	.316	.061[a]
Milk sold per man	-.265	-.005[a]	.074[a]	.248	-.076[a]	.110	.197	-.427	.541	.061[a]
Purchased food costs per cow	-.041[a]	.100	.019[a]	.160	.045[a]	-.054[a]	-.122	.085	.137	.680
Purchased food costs per cwt. milk	.066[a]	.095	.053[a]	-.091	.167	-.057[a]	-.093	.342	.062	.611

Table A1 (cont'd.)

	Machinery cost per cow	Labor per cow	Investment per man	Investment per cow	Percent days in milk	Test	Lbs. concentrate cow /yr.	Percent net energy concentrates	Percent net energy silages	Percent net energy hay	Percent net energy pasture	Avg. calving interval
Machinery costs per cow	1.00	.179	.167	.390	.154	-.030[a]	.053[a]	-.009[a]	.038[a]	-.063[a]	-.012[a]	.070[a]
Labor per cow		1.00	-.44	.232	-.027[a]	.062[a]	.195	.092	-.131	.074[a]	.050[a]	.031[a]
Investment per man			1.00	.624	.158	.002[a]	.036[a]	.006[a]	.187	-.233	-.065[a]	.049[a]
Investment per cow				1.00	.089	.026[a]	.137	.099	-.024[a]	-.057[a]	.060[a]	.078[a]
Percent days in milk					1.00	-.014	.206	-.019[a]	.222	-.274	-.192	.164
Test						1.00	-.090	.013[a]	.222	-.159	-.127	.037[a]
Lbs. concentrate cow/year							1.00	.301	-.102	-.234	-.325	.013[a]
Percent net energy concentrates								1.00	-.244	-.171	-.270	.109
Percent net energy silages									1.00	-.729	-.637	.138
Percent net energy hay										1.00	.259	-.138
Percent net energy pasture											1.00	-.041[a]
Average calving interval												1.00

Table 1A (cont'd.)

	Days dry	Breedings per conception	Percent leaving herd	Body-weight	Average milk price	Yield of corn per acre	Yield of hay per acre	Cost of producing cwt. milk	Total pound milk sold annually	Dairy concentrate price
Machinery costs per cow	-.083[a]	.099	.060[a]	.171	.061[a]	-.050[a]	.051[a]	.256	-.156	-.189
Labor per cow	.046[a]	.104	-.063[a]	.131	.209	.005[a]	-.064[a]	.232	-.118	-.075[a]
Investment per man	-.080[a]	-.027[a]	.062[a]	.129	-.001[a]	.067[a]	.152	.053[a]	.140	-.043[a]
Investment per cow	-.007[a]	.041[a]	.005[a]	.145	.067[a]	.009[a]	.046[a]	.316	-.183	-.103
Percent days in milk	-.788	.109	.136	.118	.116	.040[a]	.127	-.109	.230	-.025[a]
Test	-.046[a]	.130	.057[a]	-.360	.486	.103	.141	.184	.125	.020[a]
Lbs. concentrate cow /year	-.131	.173	.012[a]	.257	.087	.049[a]	.086	-.172	.298	-.318
Percent net energy concentrate	.087	.053[a]	-.027[a]	.004[a]	.119	-.111	-.059[a]	.074[a]	.071[a]	-.046[a]
Percent net energy silages	-.215	.040[a]	.035[a]	-.022[a]	.196	.279	.245	-.058[a]	.391	-.101
Percent net energy hay	.219	-.046[a]	.009[a]	-.045[a]	-.166	-.222	-.282	.050[a]	-.410	.159
Percent net energy pasture	.162	.127	-.073[a]	-.017[a]	-.144	-.243	-.169	.188	-.394	.224
Average calving interval	-.012[a]	.478	-.025[a]	.078[a]	.025[a]	.017[a]	-.006[a]	.102	-.074[a]	.098

Table 1A (cont'd.)

	Days dry	Breedings per conception	Percent leaving herd	Body-weight	Average milk price	Yield of corn per acre	Yield of hay per acre	Cost of producing cwt. milk	Total pound milk sold annually	Dairy concentrate price
Days dry	1.00	.024[a]	.029[a]	-.157	-.033[a]	-.039[a]	-.095	.192	-.213	.050[a]
Breedings per conception		1.00	-.020[a]	.091	.085	.042[a]	.002[a]	.024[a]	.098	.003[a]
Percent leaving herd			1.00	-.142	.074[a]	-.095	.006[a]	.124	.022[a]	.029[a]
Bodyweight				1.00	-.082	.053[a]	.039[a]	-.236	.184	-.023[a]
Average milk price					1.00	.011[a]	.046[a]	.217	.171	.010[a]
Yield of corn per acre						1.00	.293	-.167	.145	-.082
Yield of hay per acre							1.00	-.137	.204	-.151
Cost of producing cwt. milk								1.00	-.273	.198
Total pounds milk sold annually									1.00	-.072[a]
Dairy concentrate price										1.00

a. Not significantly different from zero at .05 level.